2017 NASA PMM Science Team Meeting, October 16-20, 2017, San Diego, CA, USA

The GPM Validation Activity over the Korea

19 October 2017

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3 Weather Radar Center, KMA
4 Numerical Modelling Center, KMA

KMA

Outline

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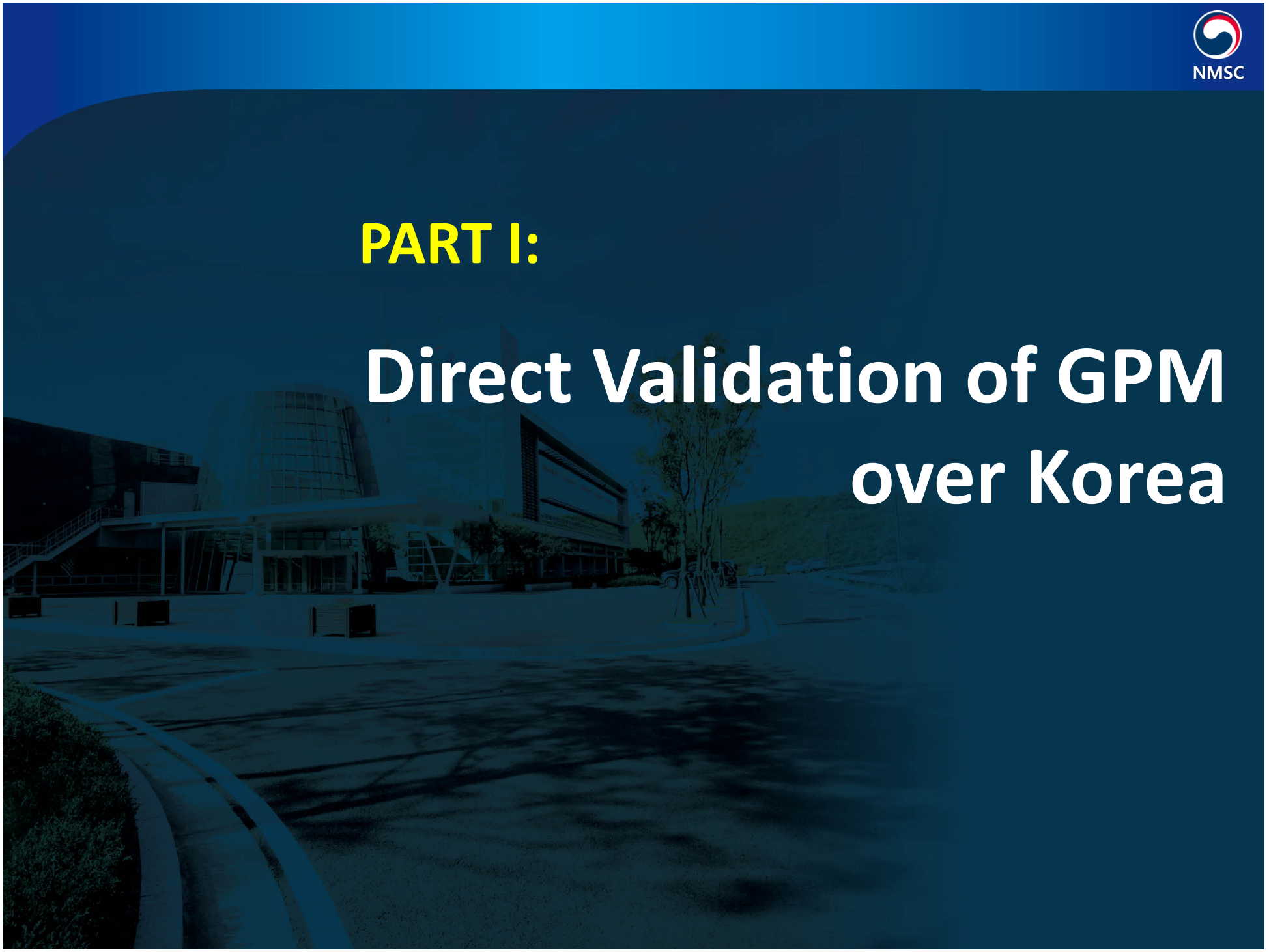
- **Direct Validation of GPM over the Korea (Part I)**
  - Summer time ground validation using VN over the Korea
  - Quick evaluation of improvement from V4 to V5 over the Korea
  - Snowfall validation over DFS(Digital Forecast System) frame
- **KMA Radar System Improvement (Part II)**
  - Dual-pol. Radar system Replacement status
  - RAR system improvement
- **ICE-POP 2018 (Part III)**
  - Progress of ICE-POP 2018



PART I:

Direct Validation of GPM over Korea

Validation Network over the Korea

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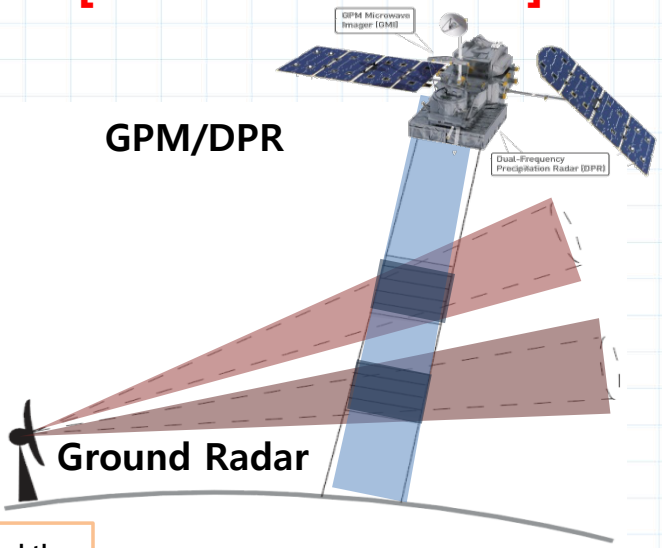
[Validation Network]



Period : 3months (Jun. ~ Aug. 2017)

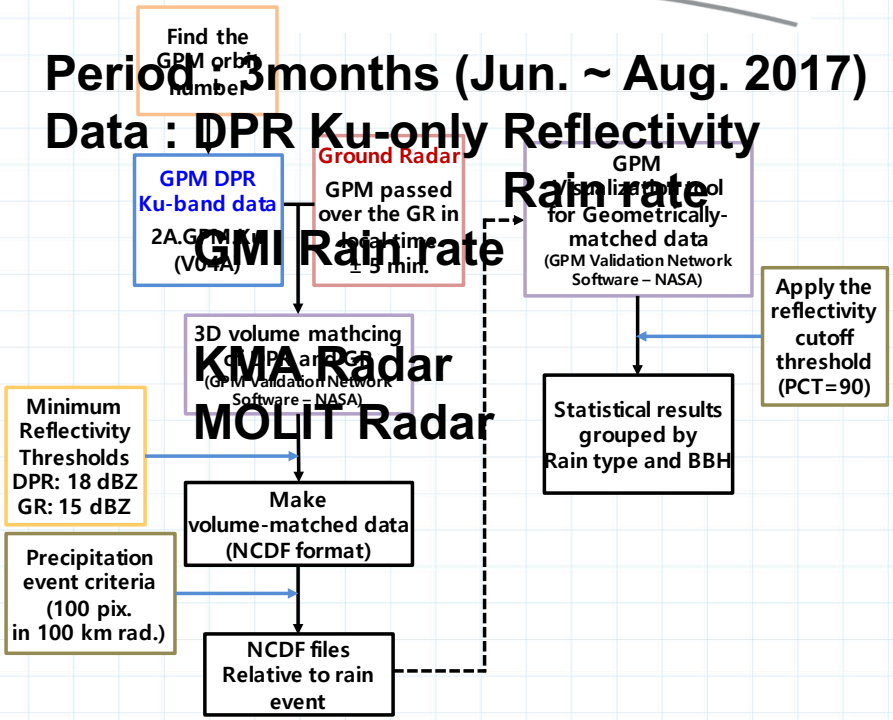
Data : DPR Ku-only Reflectivity

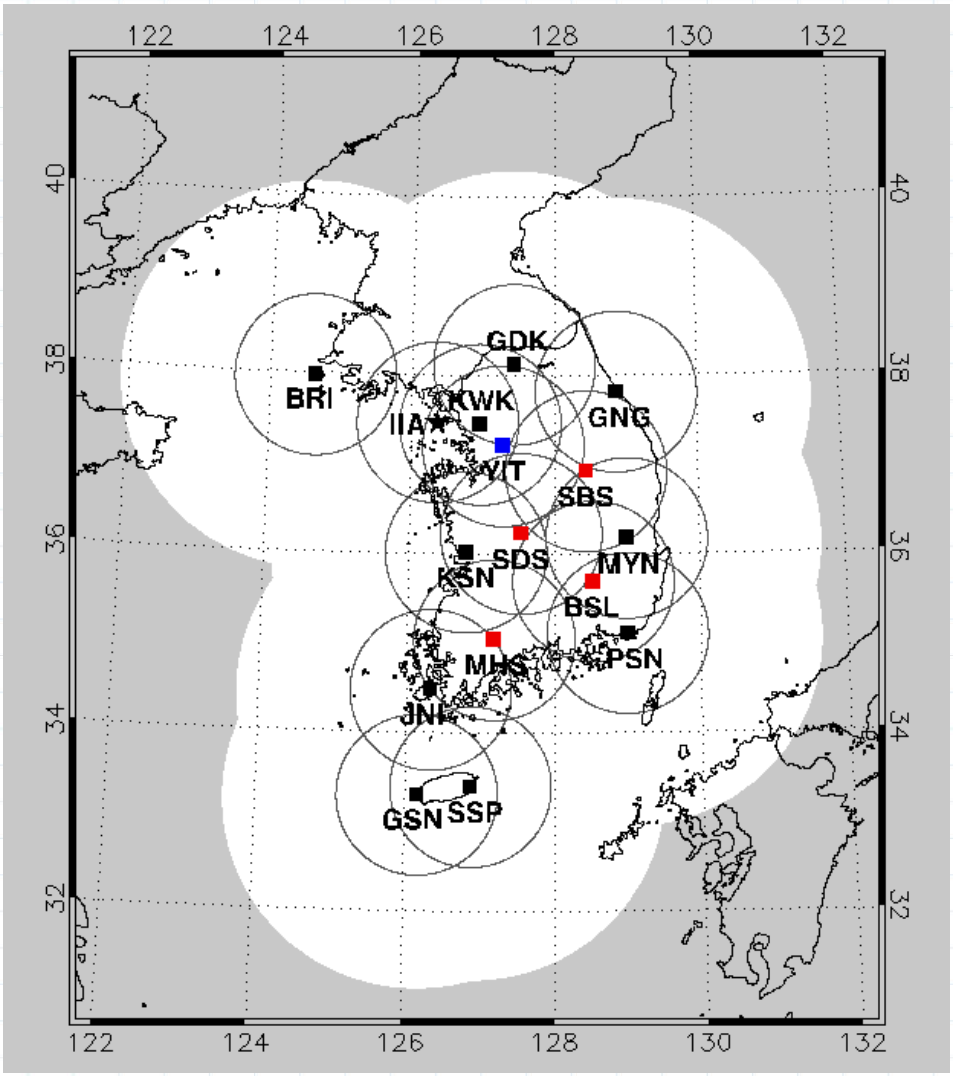
Rain rate

GMI Rain rate

KMA Radar

MOLIT Radar





Black : KMA ground radar

Blue : KMA test-bed

Red : MOLIT ground radar

MOLIT : Ministry of Land, Infrastructure and Transport

Reflectivity Comparison Statistics (KMA sites)

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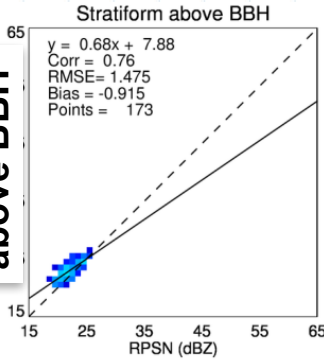
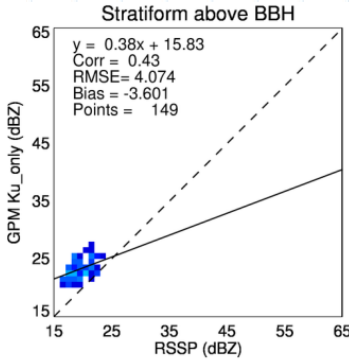
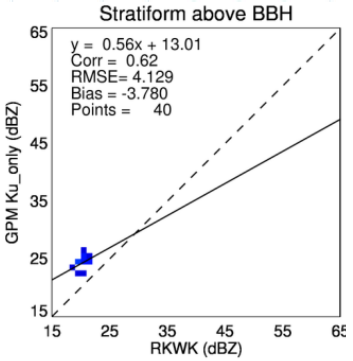
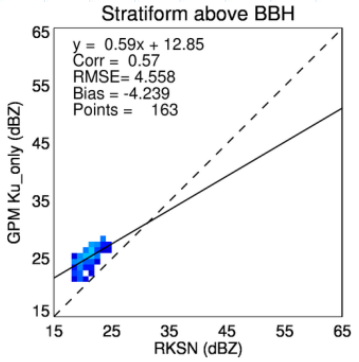
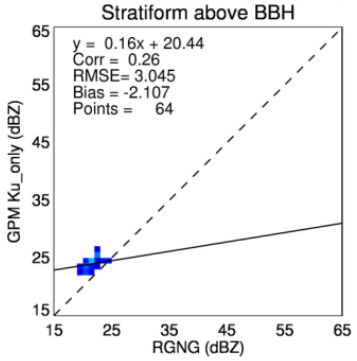
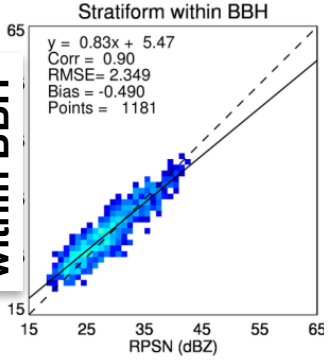
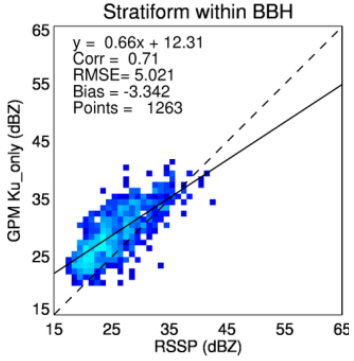
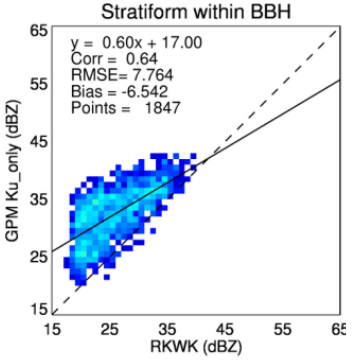
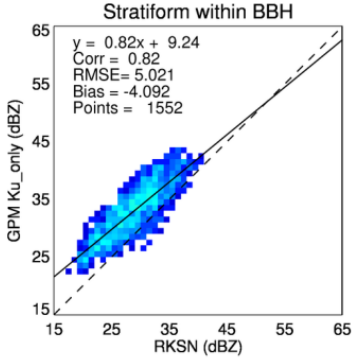
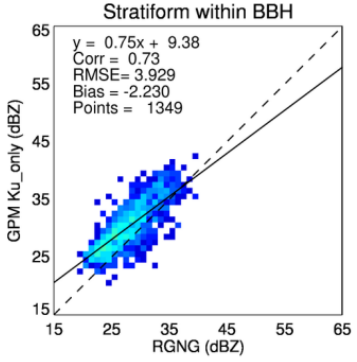
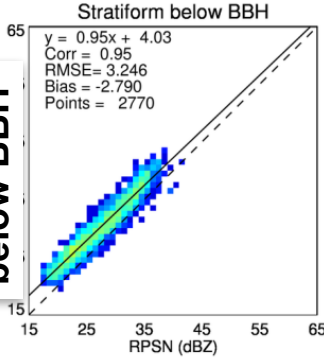
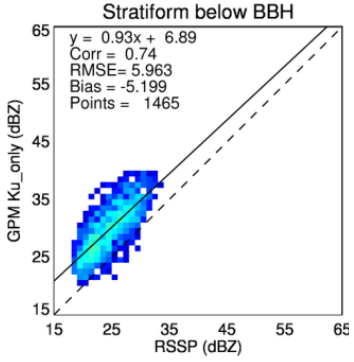
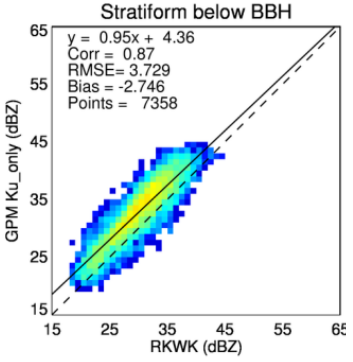
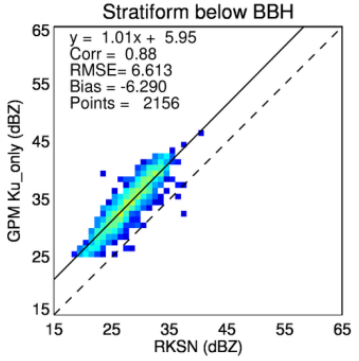
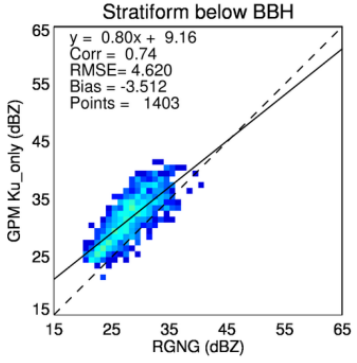
	PSN	SSP	KWK	KSN	GNG
above BBH					
within BBH					
below BBH					

Reflectivity Comparison Statistics (MOLIT sites)

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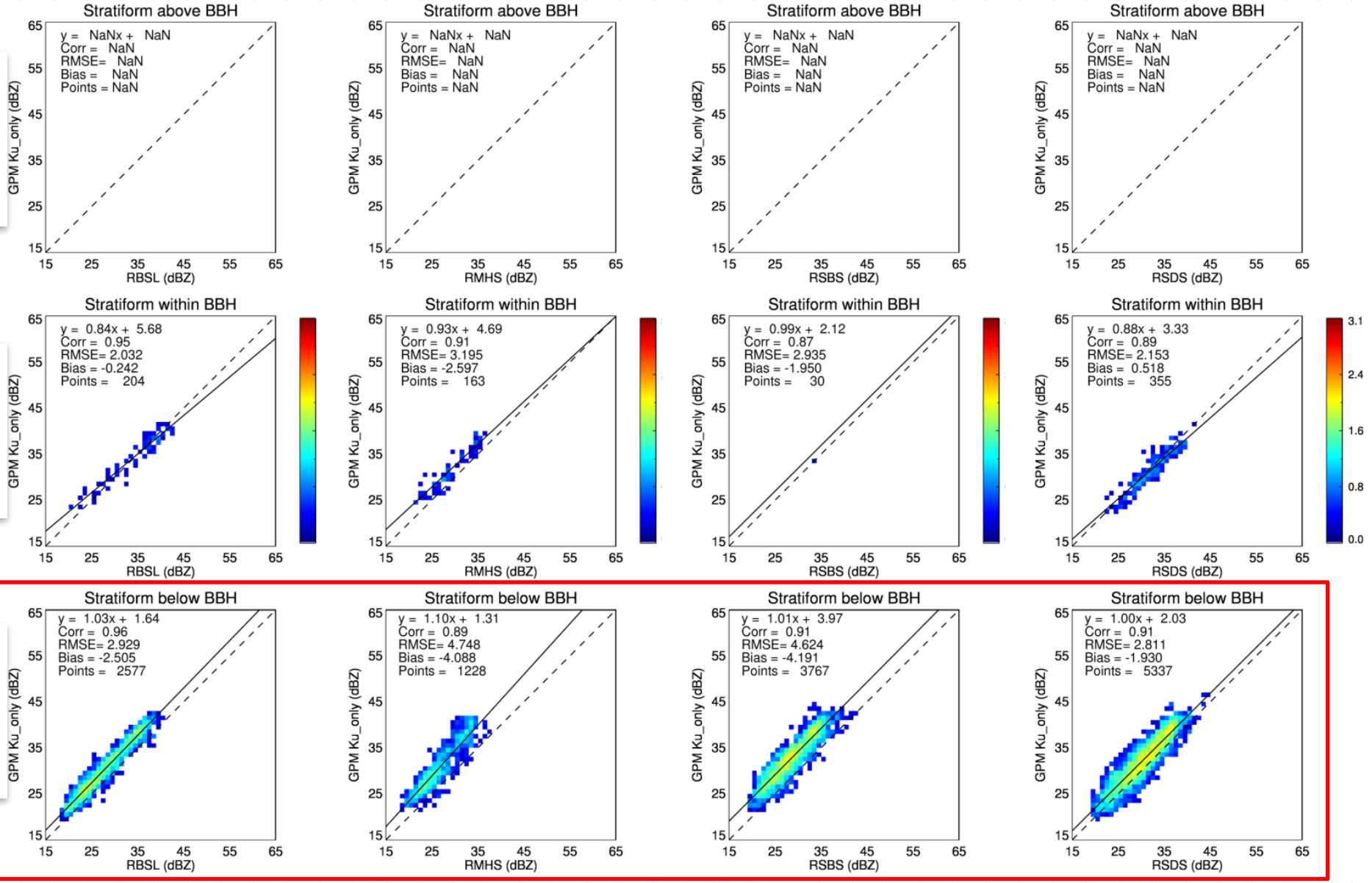
	Biseul	Mohu	Sobaek	Seodae
above BBH	Stratiform above BBH y = NaNx + NaN Corr = NaN RMSE= NaN Bias = NaN Points = NaN	Stratiform above BBH y = NaNx + NaN Corr = NaN RMSE= NaN Bias = NaN Points = NaN	Stratiform above BBH y = NaNx + NaN Corr = NaN RMSE= NaN Bias = NaN Points = NaN	Stratiform above BBH y = NaNx + NaN Corr = NaN RMSE= NaN Bias = NaN Points = NaN
within BBH	Stratiform within BBH y = 0.84x + 5.68 Corr = 0.95 RMSE= 2.032 Bias = -0.242 Points = 204	Stratiform within BBH y = 0.93x + 4.69 Corr = 0.91 RMSE= 3.195 Bias = -2.597 Points = 163	Stratiform within BBH y = 0.99x + 2.12 Corr = 0.87 RMSE= 2.935 Bias = -1.950 Points = 30	Stratiform within BBH y = 0.88x + 3.33 Corr = 0.89 RMSE= 2.153 Bias = 0.518 Points = 355
below BBH	Stratiform below BBH y = 1.03x + 1.64 Corr = 0.96 RMSE= 2.929 Bias = -2.505 Points = 2577	Stratiform below BBH y = 1.10x + 1.31 Corr = 0.89 RMSE= 4.748 Bias = -4.088 Points = 1228	Stratiform below BBH y = 1.01x + 3.97 Corr = 0.91 RMSE= 4.624 Bias = -4.191 Points = 3767	Stratiform below BBH y = 1.00x + 2.03 Corr = 0.91 RMSE= 2.811 Bias = -1.930 Points = 5337



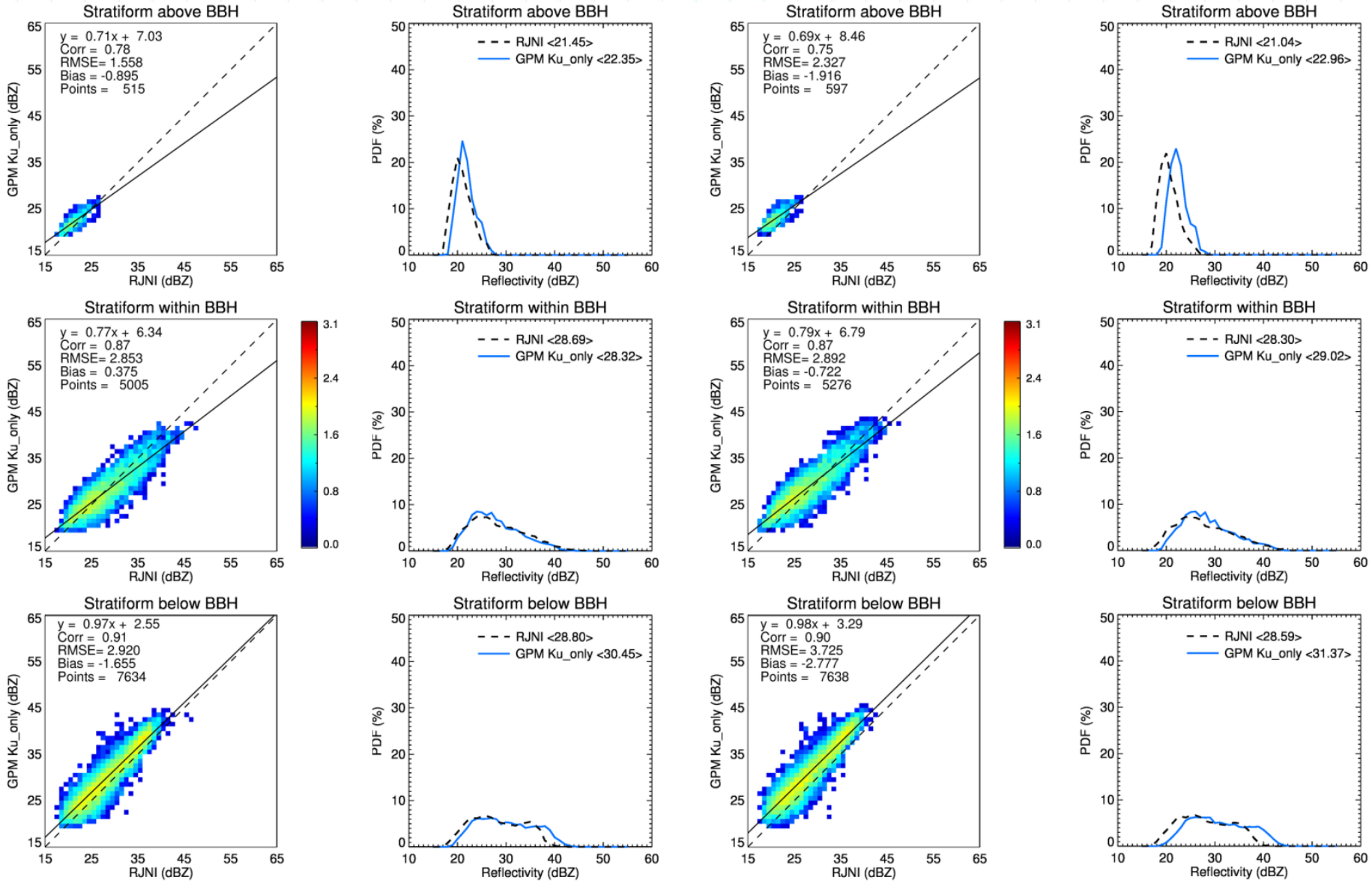
Quick Evaluation of Algorithm improvement @Jindo

NMSC

V4

Period: Mar. 2016 ~ Feb. 2017

V5



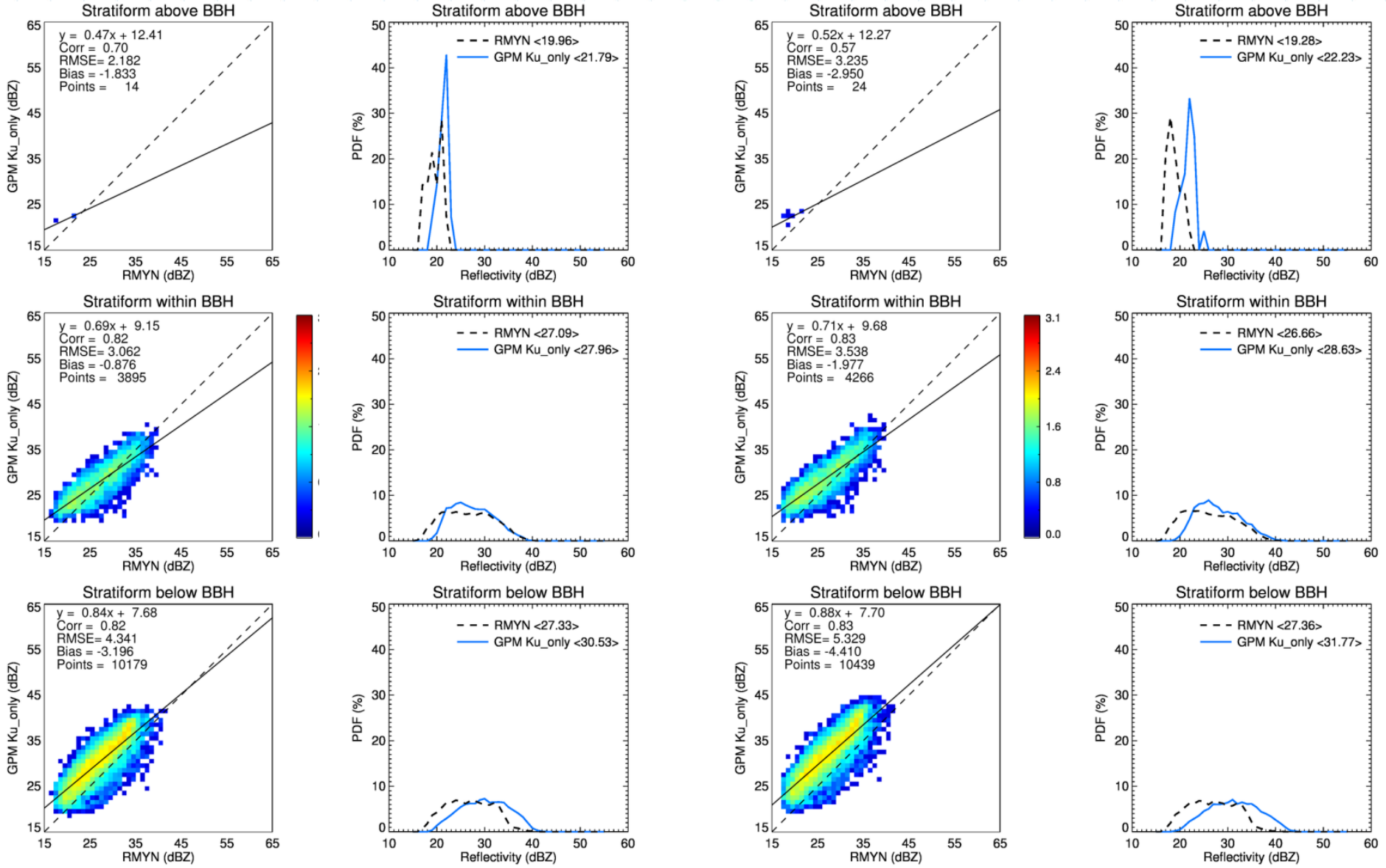
Quick Evaluation of Algorithm improvement @Myunbong

NMSC

V4

Period: Mar. 2016 ~ Feb. 2017

V5

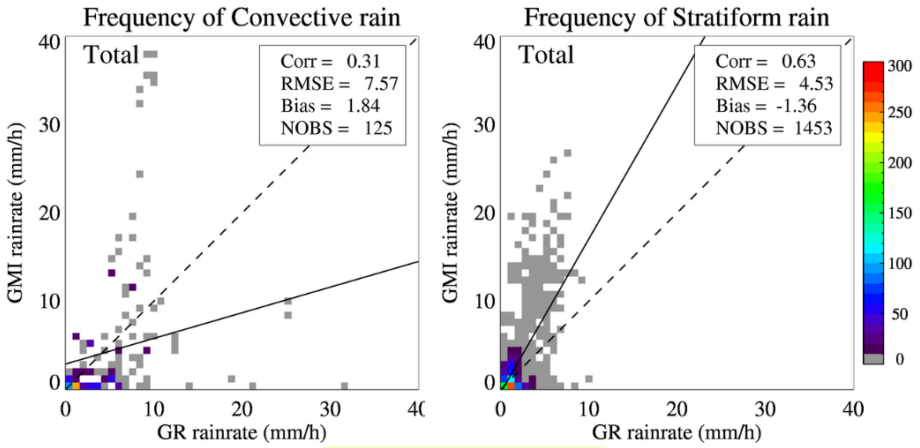


Quick Evaluation of Algorithm improvement @Jindo

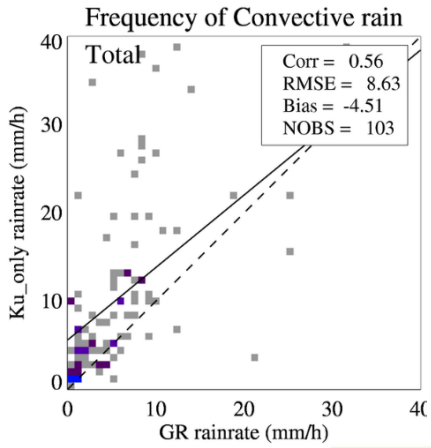
NMSC

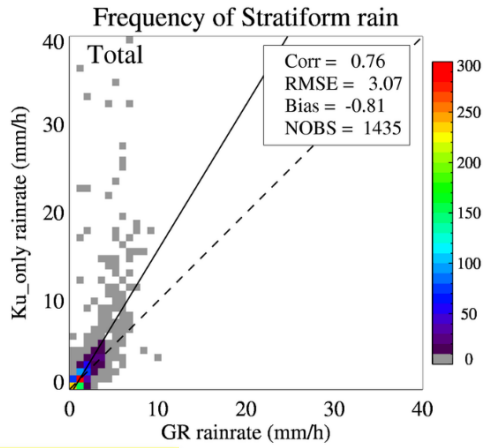
V4

GMI



DPR_Ku

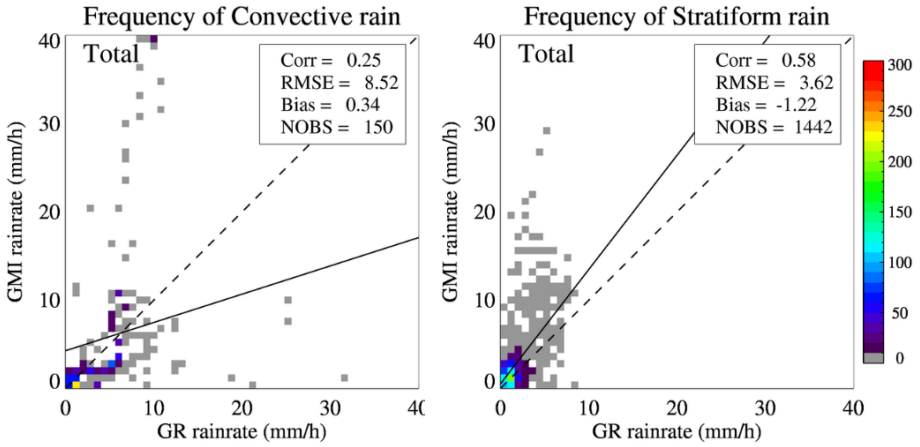


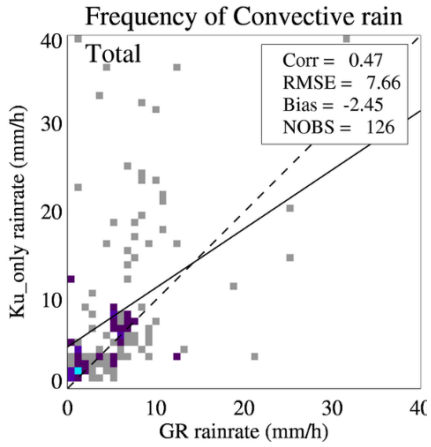


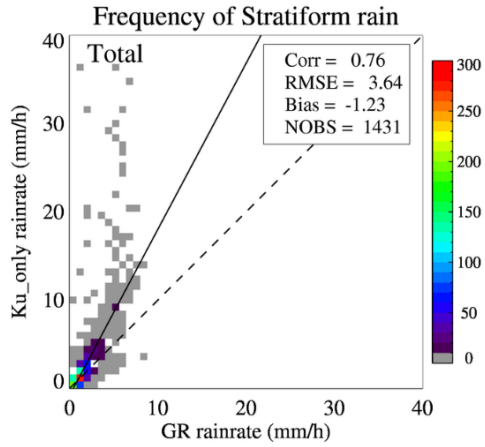
Better

So So

V5





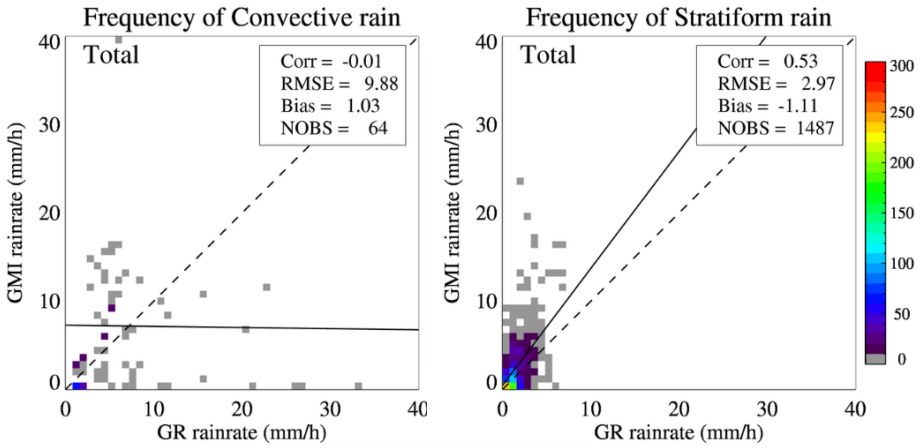


Quick Evaluation of Algorithm improvement @Myunbong

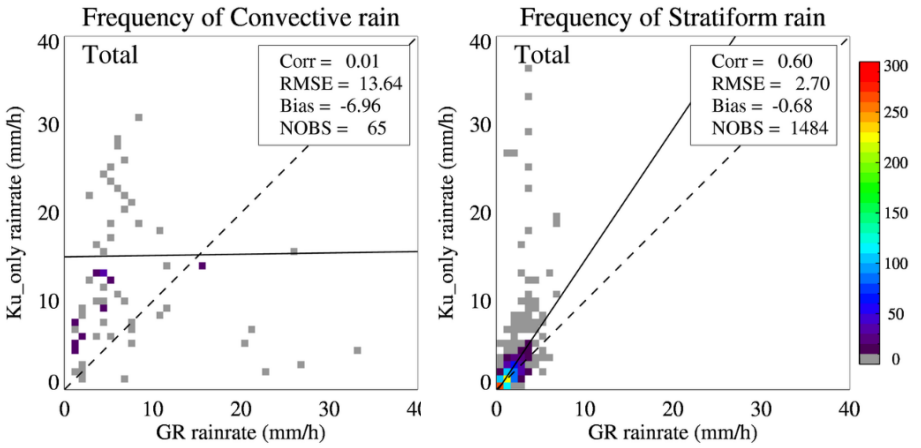
NMSC

V4

GMI



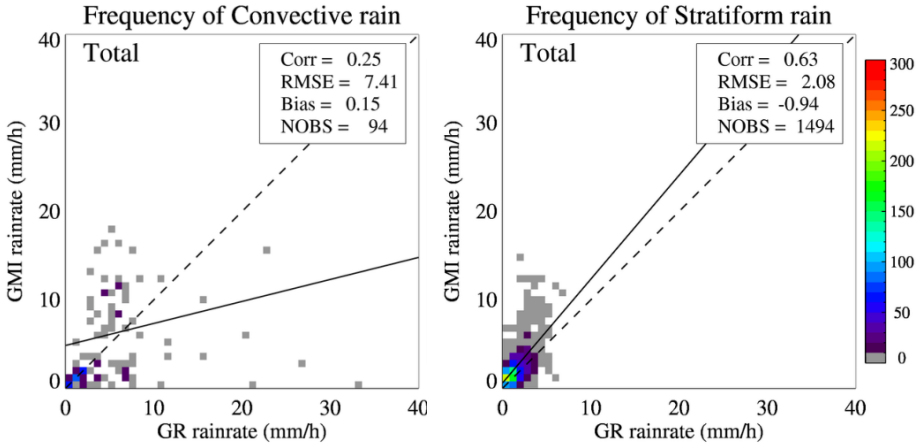
DPR_Ku

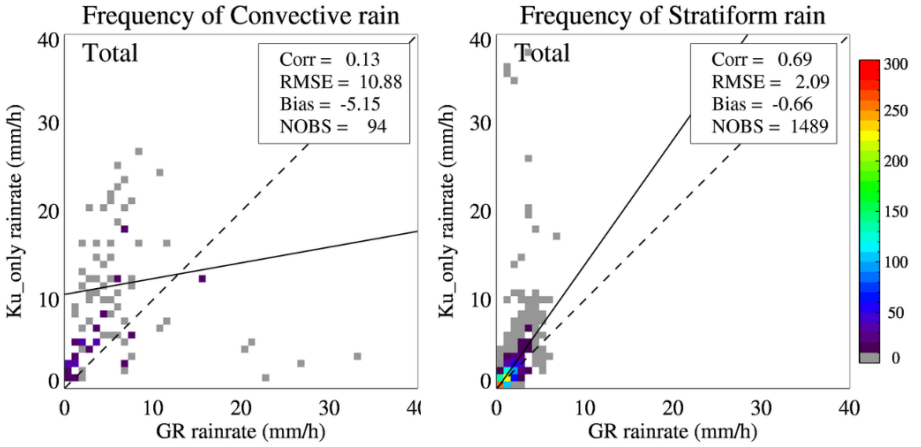


Better

So so

V5





Application DFS for GPM GV

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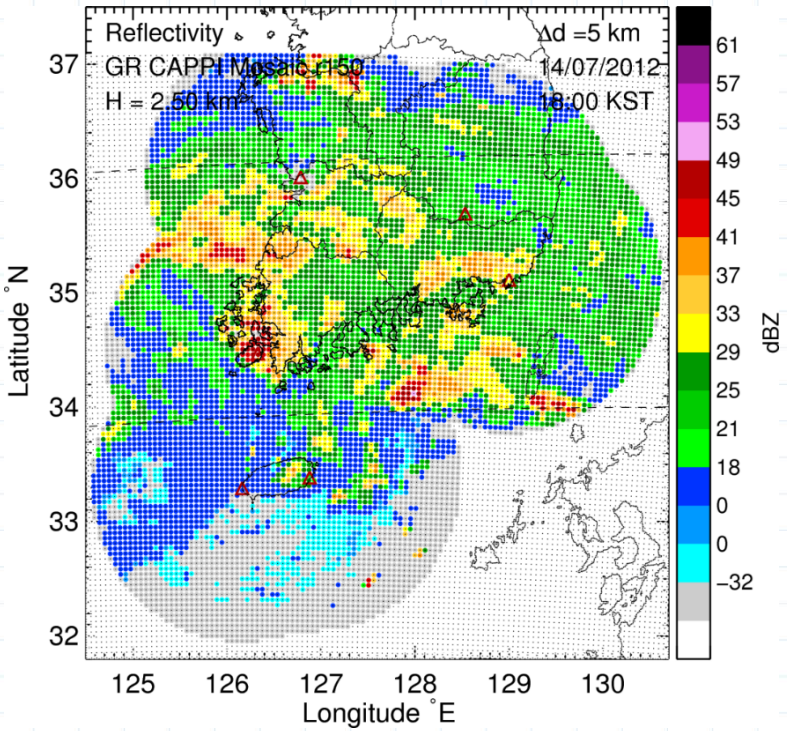
- **Digital Forecast System (DFS)**

✓ KMA operates the DFS to provide village scale forecasts up to 2 days.

✓ DFS uses fixed grid projected on Lambert conformal conic map.

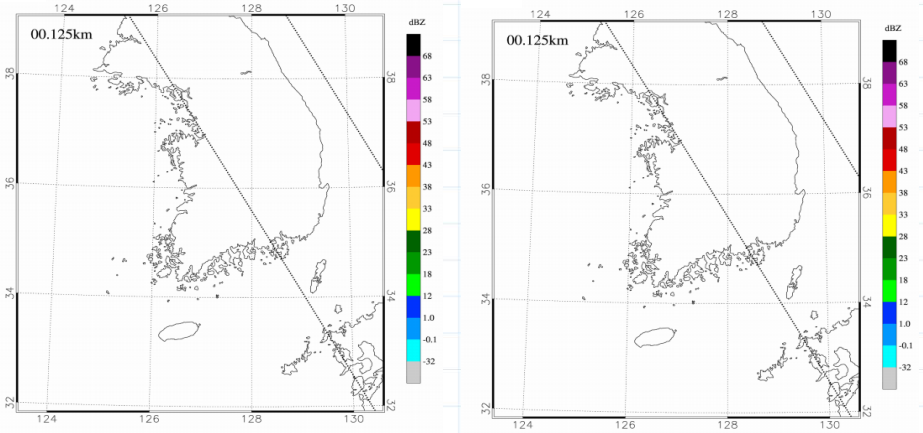
✓ Horizontal resolution can be changed from 5 km to 35 km.



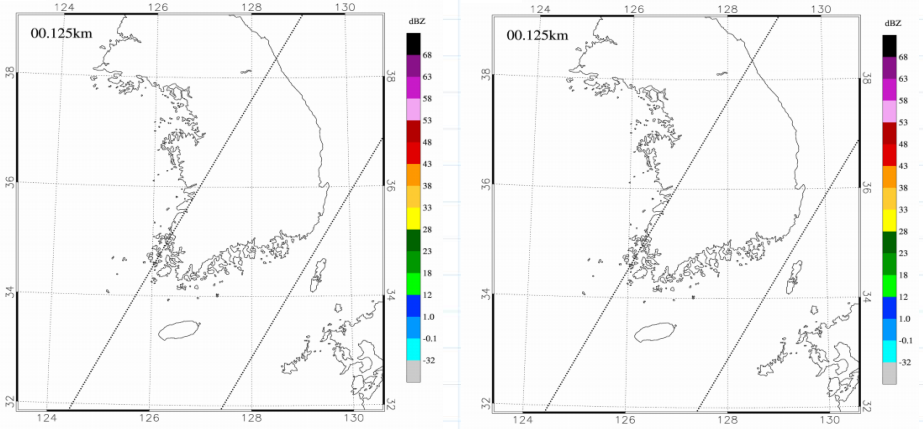
[GR reflectivity over DFS coordinates]

Ground radar **GPM Ku**

1st July 2016 09:30 UTC



4th October 2016 20:30 UTC



DPR L3 snowfall validation

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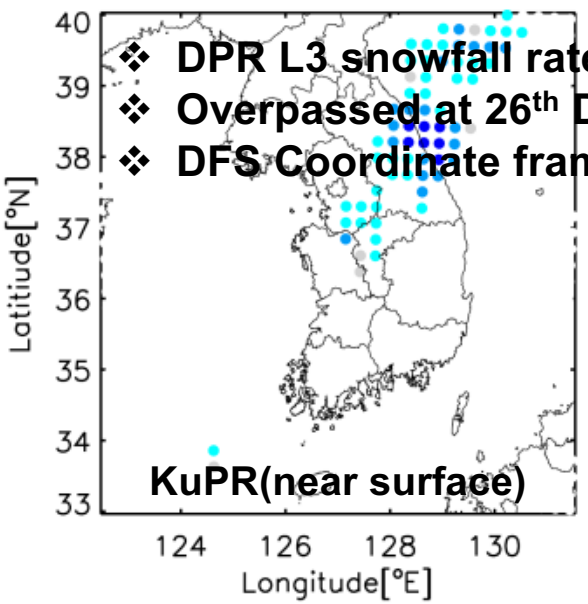
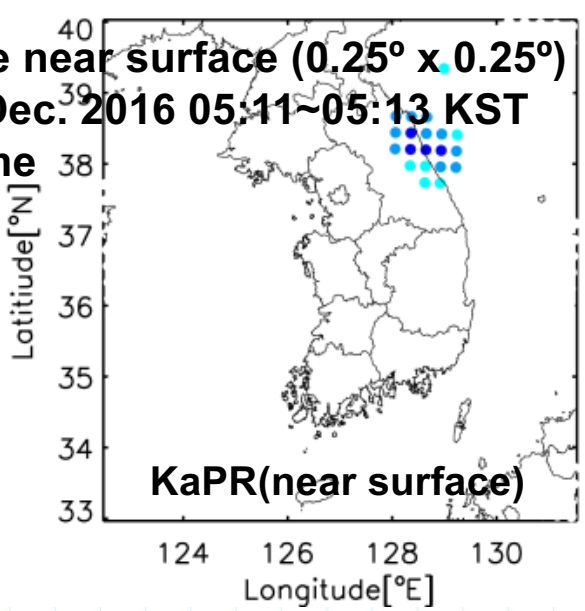
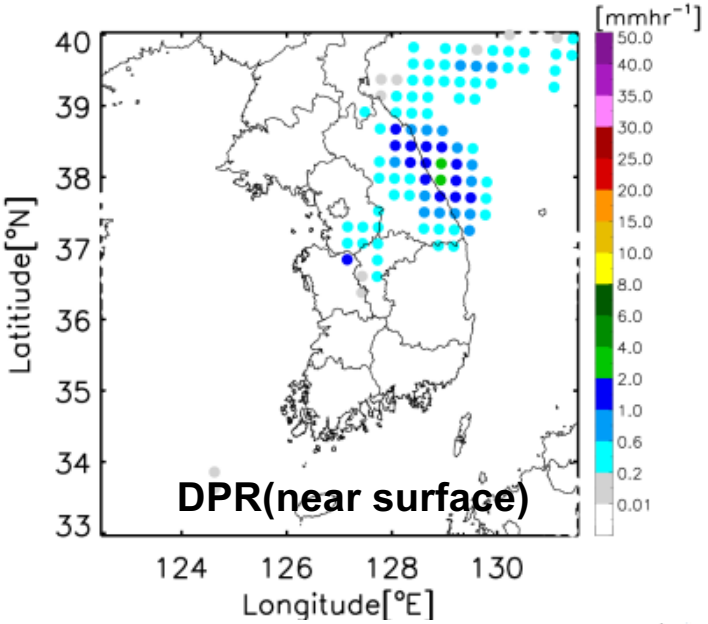
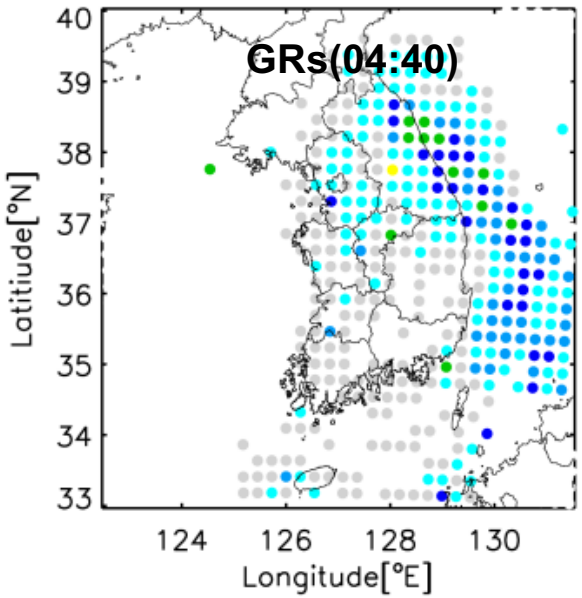
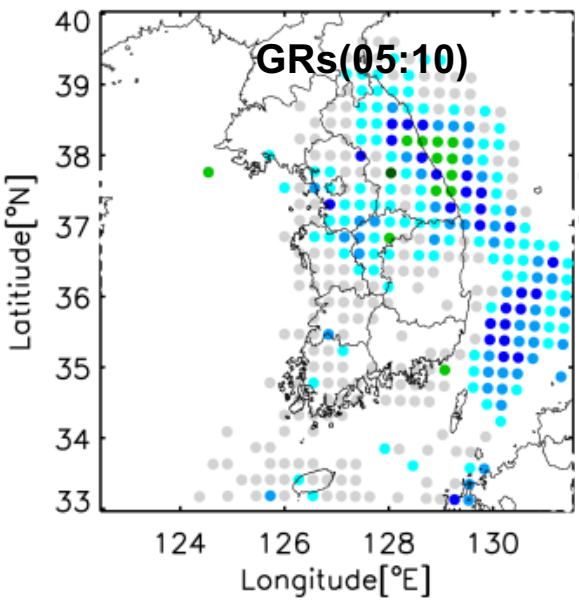
- DPR L3 snowfall rate near surface (0.25º x 0.25º)
- Overpassed at 26th Dec. 2016 05:11~05:13 KST
- DFS Coordinate frame

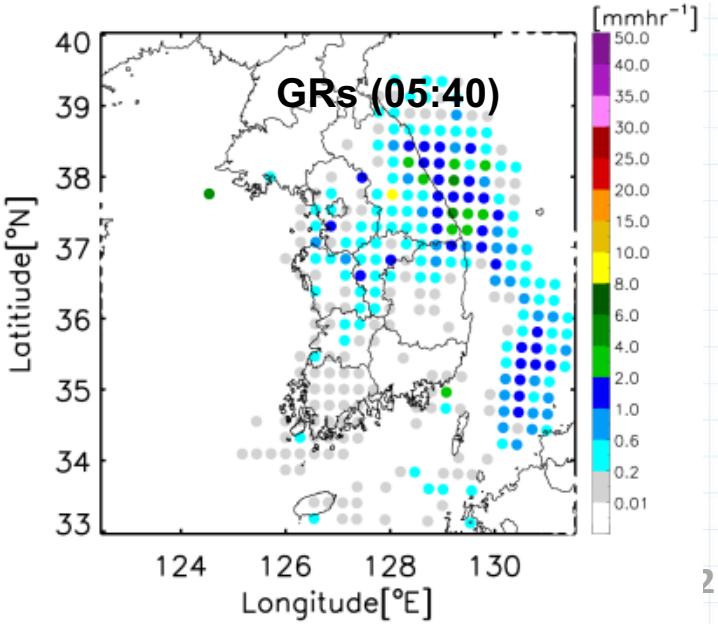












DPR L3 snowfall validation

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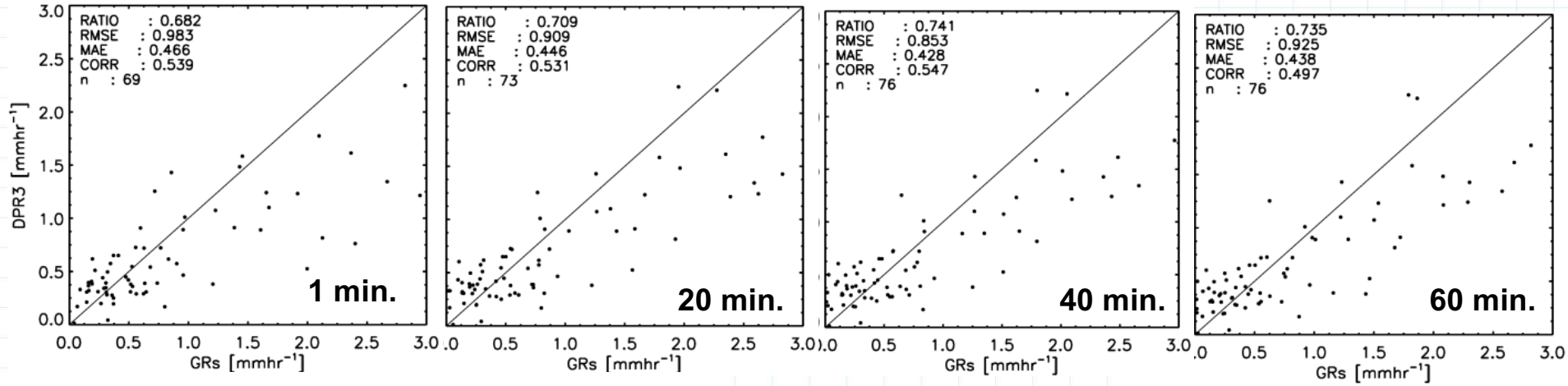
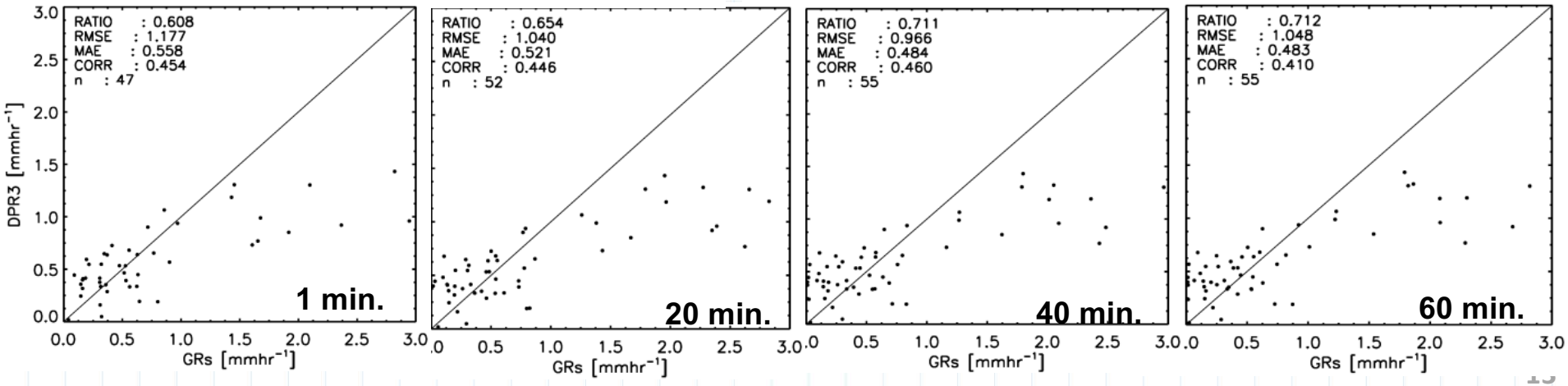
KuPR vs. Radars (Time ave., 1x1 grids)



DPR vs. Radars (Time ave., 1x1 grids)

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PART II:
KMA Radar System
Improvement

Replacement to S-band dual polarization radar

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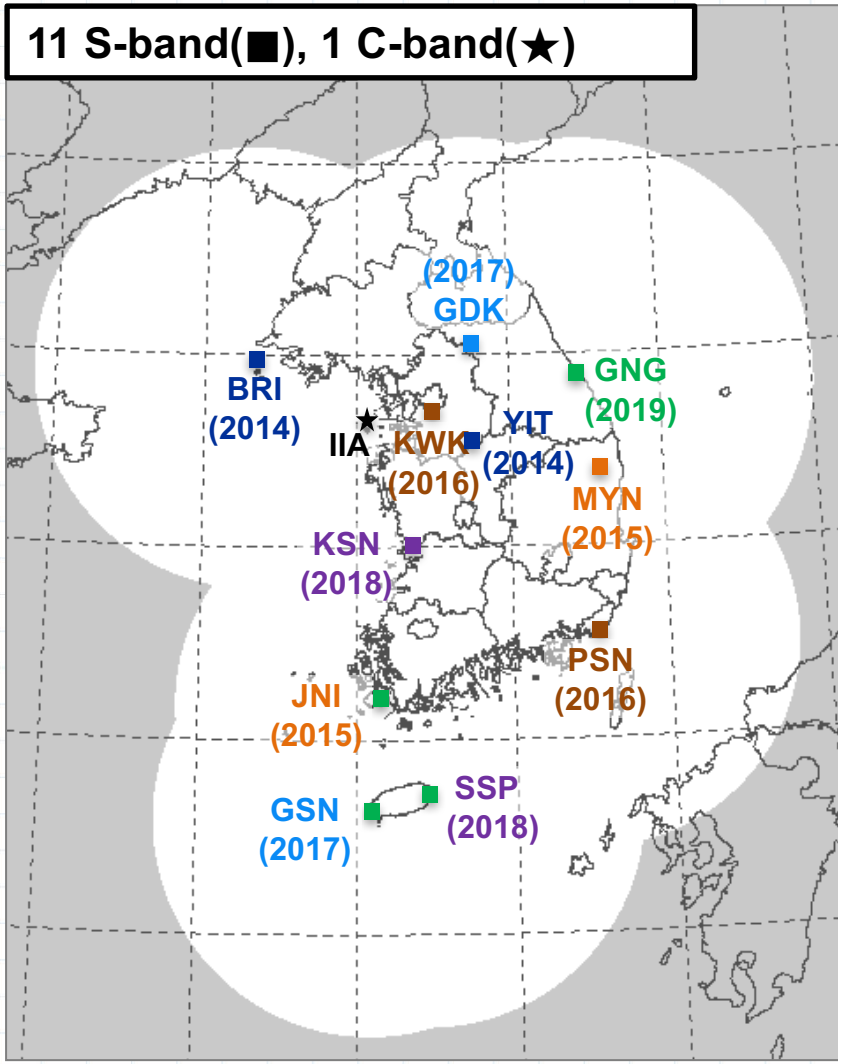
Year	2014	2015	2016	2017	2018	2019
Site	BRI YIT	JNI MYN	KWK PSN	GDK GSN	KSN SSP	GNG

KMA replaces radar system to S-band dual polarization radar from 2013 to 2019.



RAR (Radar-AWS Rainrate)

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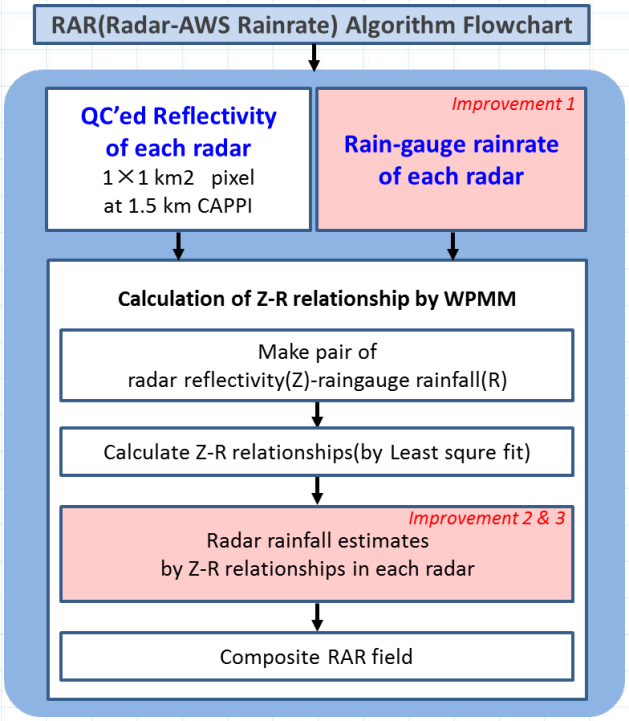
Courtesy of Sang-Mi Lee

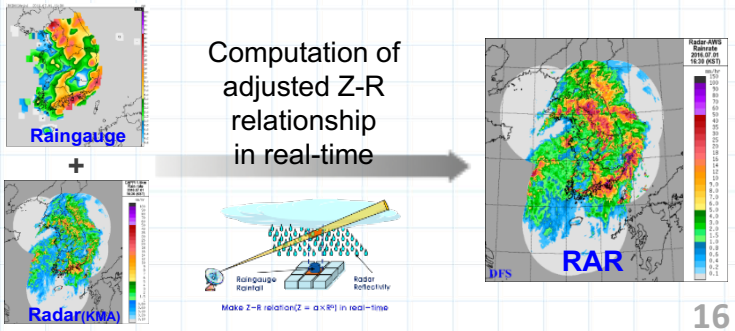
RAR in KMA

- KMA has developed the adjustment techniques of radar rainfall based on rain gauges measurement, Radar-AWS Rainrate (RAR).
- RAR system provides the gauge-adjusted radar rainrate in real time by applying new coefficient ‘a’ and exponent ‘b’ in radar Z-R relationship based on window probability matching method every 10 minutes are derived from pairs between radar reflectivity and gauge rainrate.

	Radar	AWS	RAR
Observation Range	11 radars (All sites : S-band)	642 points in Korea Peninsula	Composition of 11 KMA radars
Spatial Resolution	1km*1km (240km range)	about 13 km	1241*1761(1 km)
Time Resolution	10 min	1 min	10 min
Unit	dBZ	mmhr-1	mmhr -1

RAR Algorithm





Problem of current RAR

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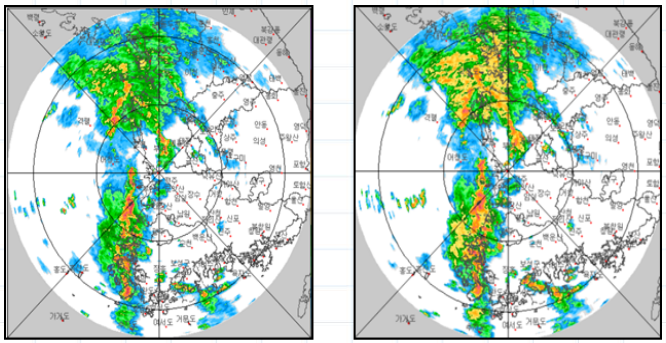
Courtesy of Sang-Mi Lee

- Sometimes RAR shows unrealistic temporal discontinuity

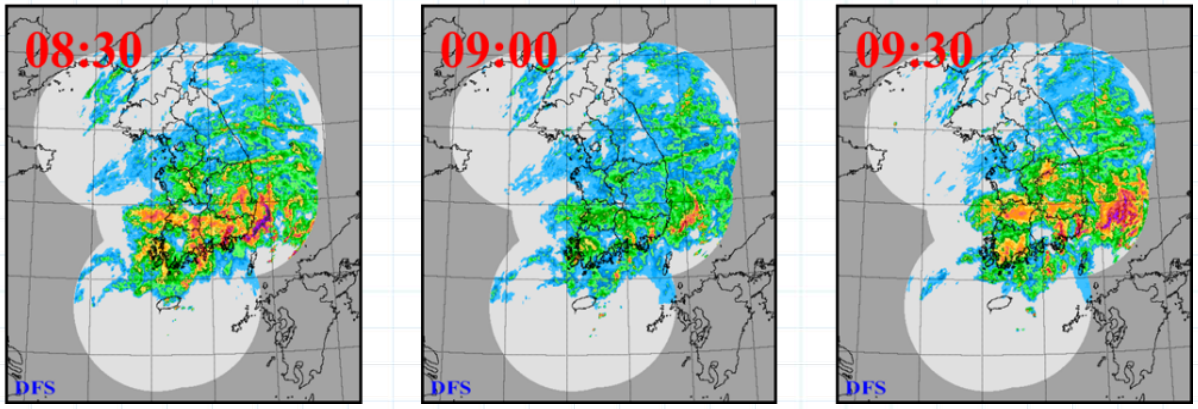
  - at the beginning of WPMM



06:10
: default relation

06:20
: real-time relation
from RAR

  - Unstable ‘a’ and ‘b’



Improvement of RAR system

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Courtesy of Sang-Mi Lee

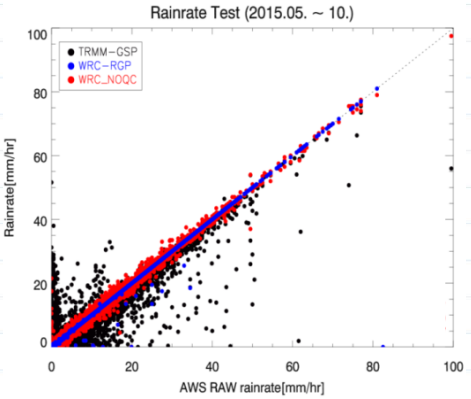
In order to obtain stable RAR rainfield

1. Improvement Rainfall QC procedure

Weather Radar Center-Rain Gauge Process (WRC-RGP, *WRC, 2016*)

This program provides a list of available rain gauges within a certain radius of radar, and calculate accumulated rainfall data according to quality control method*, and time resolution selected by user. WRC-RGP has *improved quality control performance* for raingauge rainfall, and also *reduced computation time* for QC-process.

(*Quality Control : Integrity check, Physical limit check, Checking temporal consistency, Climatological Check)

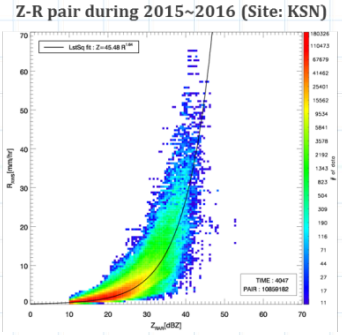


2. Applying Mean Coefficient to default relationship

The new coefficients are derived only when the number of pairs between radar rainfall estimates and rain gauge rainfall are enough. Otherwise, Marshall-Palmer (M-P) Z-R relationship is applied as a default relationship. The use of M-P relationship induces temporal discontinuity of RAR.

In order to obtain stable RAR rain field, we've calculated the mean Z-R relationship for each radar sites.

(Period : March~October, 2015 and 2016)



3. Error Weighted correcting method to improve temporal stability

The Z-R relationship calculated in real-time is calculated independently every 10 minutes, several discontinuity exists in RAR system. We used bias correction method to reduce temporal discontinuity of rain fields

$$R_{qped} = \frac{rRMSE_2}{rRMSE_1+rRMSE_2} * R_1 + \frac{rRMSE_1}{rRMSE_1+rRMSE_2} * R_2$$

R_{qped} = Error Inverse corrected Rainrate
R_1 = QPED by Real-time Z-R relation
R_2 = QPED by Mean Z-R relation
$rRMSE_1$ = rRMSE from Real-time Z-R relation
$rRMSE_2$ = rRMSE from Mean Z-R relation

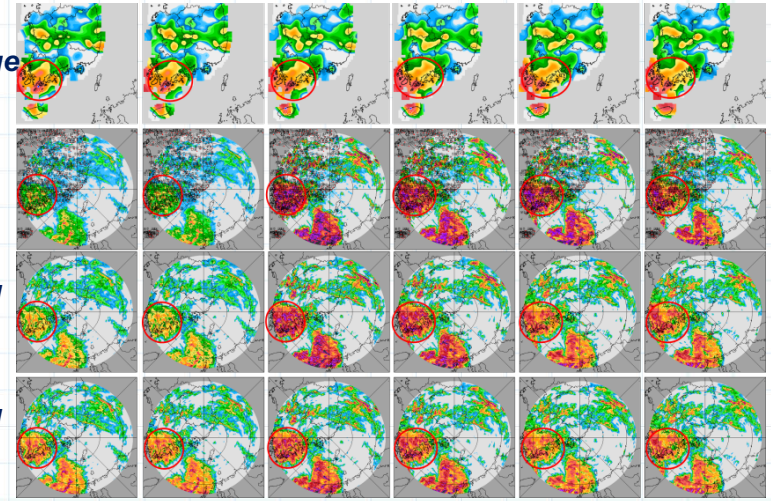
Improved RAR

NMSC

Courtesy of Sang-Mi Lee

Case of Improved RAR system

- *Case period: 14 APR 2017 05:40KST~06:30KST*



Applying Mean Z-R relation as default relationship and bias correction method on estimating precipitation in real-time, the amount of temporal changing impact in RAR system was relaxed.

- *Improved RAR' : applying site mean Z-R relation as default relationship*
- *Improved RAR" : applying site mean Z-R relation as default relationship + Error Weighting Corrected*

Verification score of Improved RAR

- *Case period: 14 APR 2017 00:00KST~16:00KST*

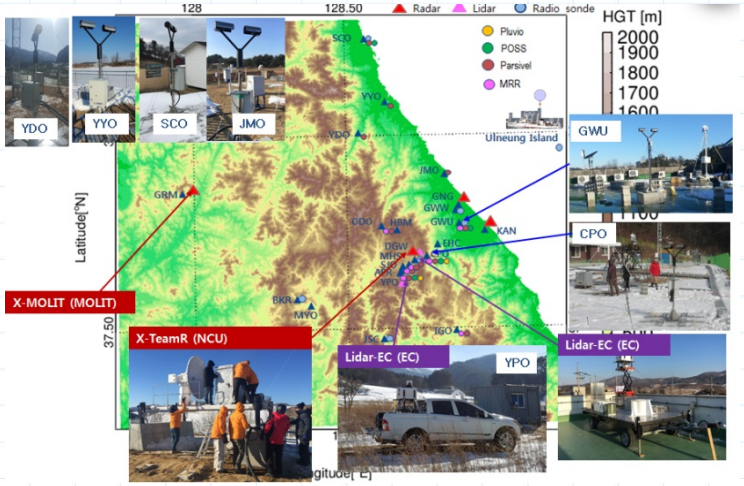
	Operational RAR	Improved RAR'	Improved RAR"
BIAS	-0.441	**-0.322**	**-0.222**
RMSE	5.398	**4.162**	**4.074**
CORR	0.478	**0.569**	**0.586**


NMSC
PART III:
ICE-POP 2018

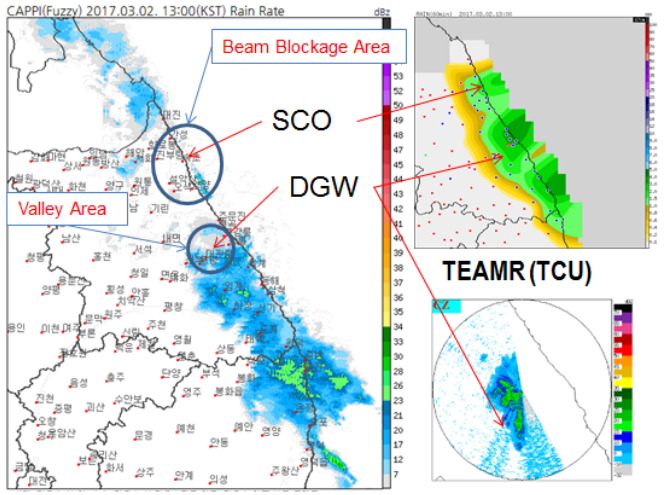
Progress

- Experiments of Observation and NWP during test event (Nov - Mar 2016/2017)

  - IOP: 1 radar, 2 lidar, 8 Parsivel, 5 POSS, 2 sonde sites(3 hourly for case)

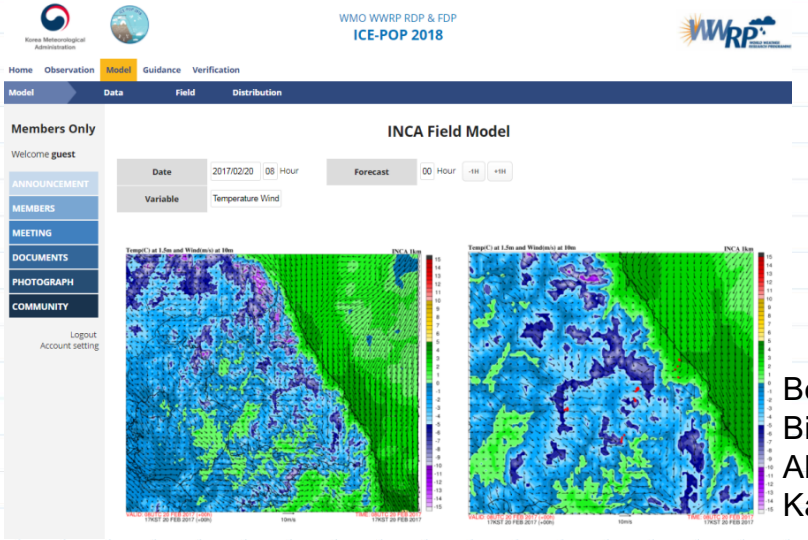


Francisco Tapidor Stella Melo Yu-Chieng Liou



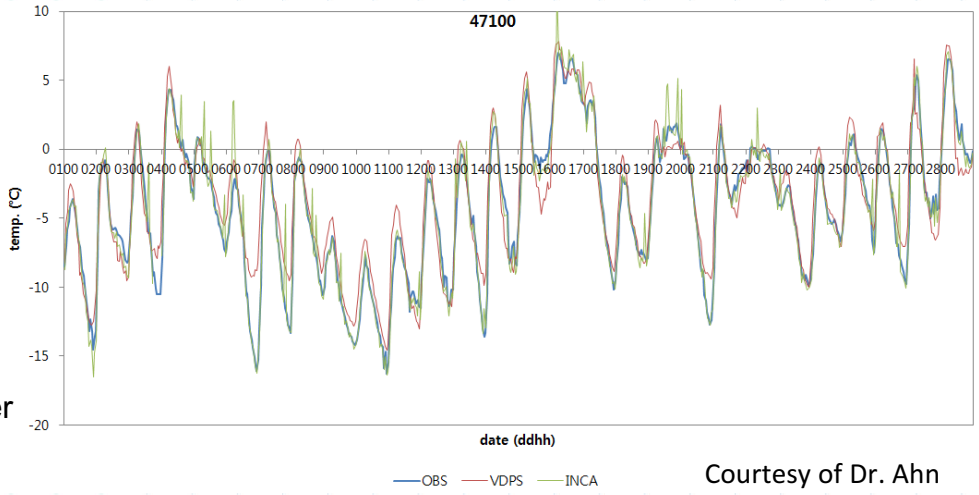
→ Need to deploy radar on SCO and DGW

  - INCA based on LDAPS



Benedikt Bica Alexander Kann

  - Verification of Corrected INCA



Courtesy of Dr. Ahn

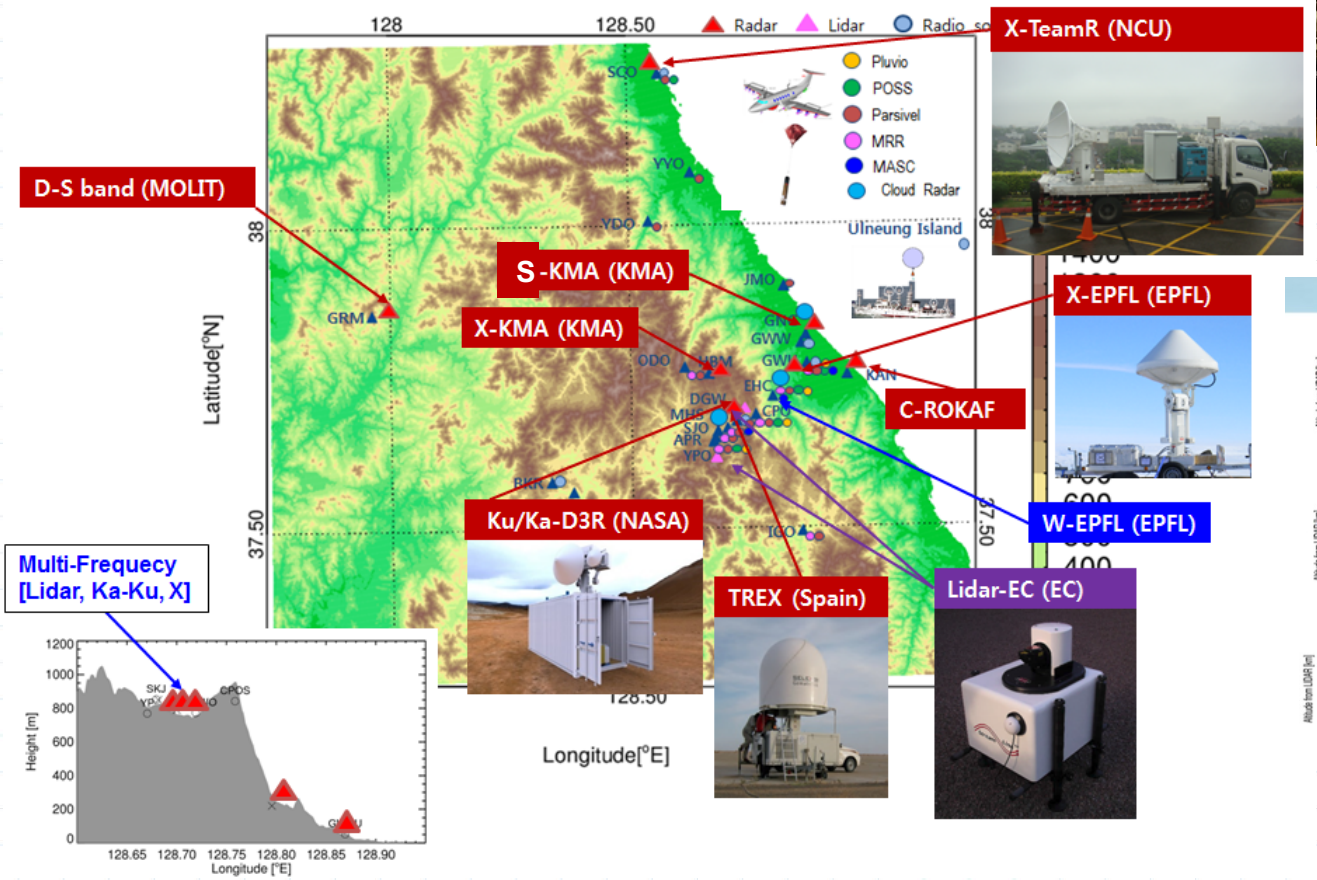
Progress

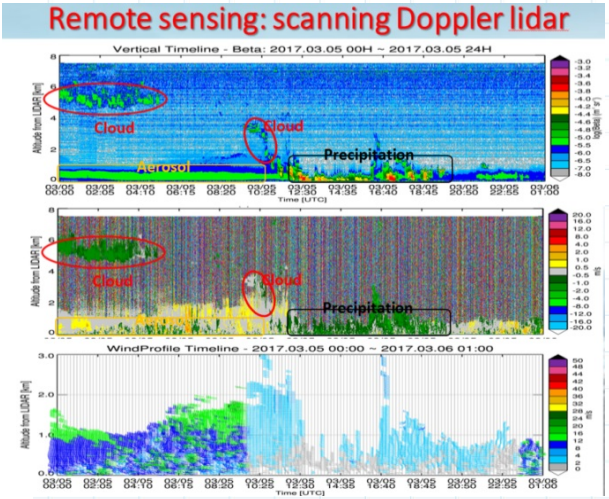
- Observation WG meeting (Mar., Sep. 2017)

  - Improve IOP plan

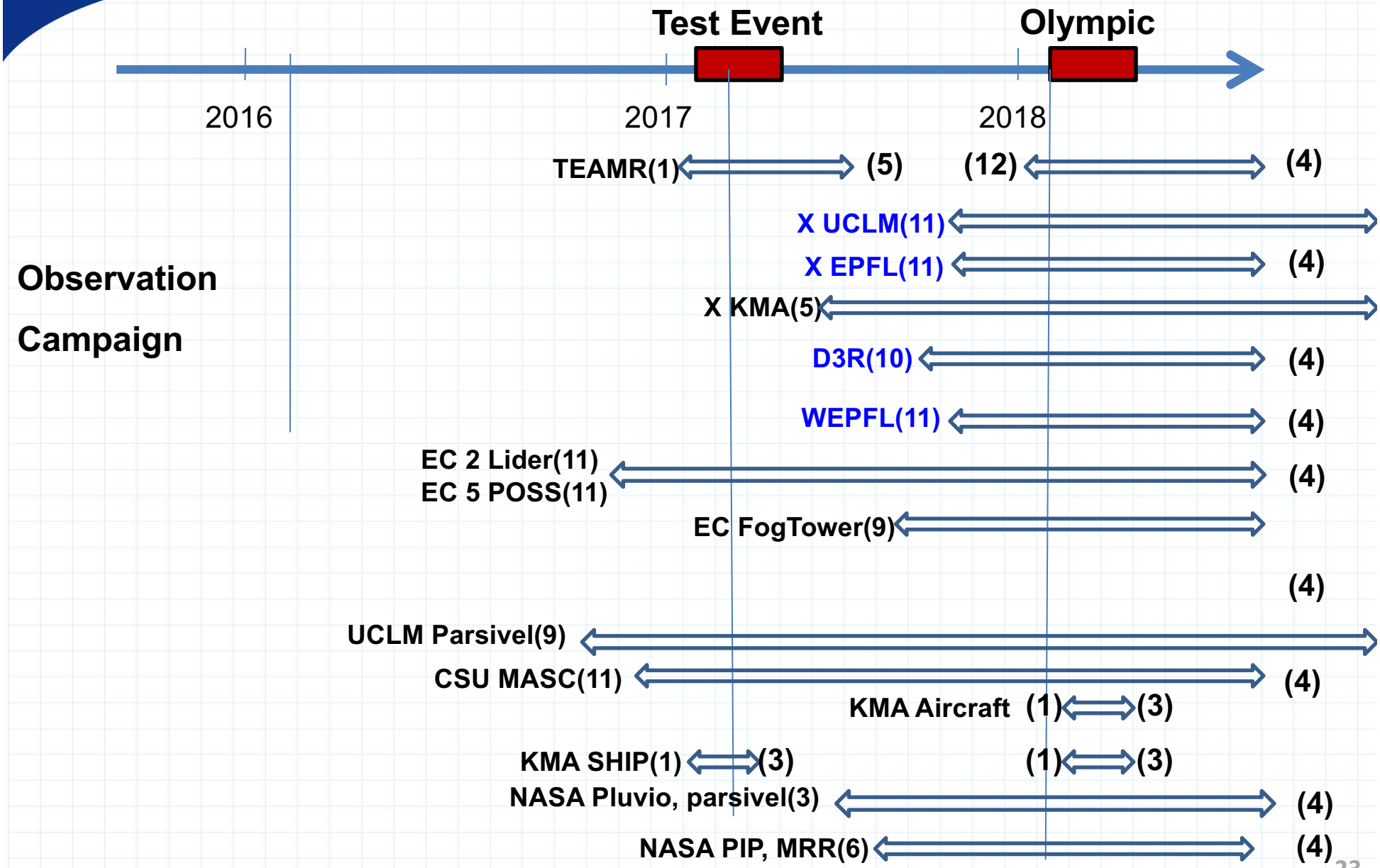
    from initial IOP(TEAMR, Lidar, Parsivel) in 2016/2017

  - Timeline for radar deployments





Timeline


Test Event
Olympic
2016
2017
2018
Observation
Campaign
TEAMR(1)
(5)
(12)
(4)
X UCLM(11)
X EPFL(11)
(4)
X KMA(5)
D3R(10)
(4)
WEPFL(11)
(4)
EC 2 Lider(11)
EC 5 POSS(11)
(4)
EC FogTower(9)
(4)
UCLM Parsivel(9)
CSU MASC(11)
(4)
KMA Aircraft
(1)
(3)
KMA SHIP(1)
(3)
(1)
(3)
NASA Pluvio, parsivel(3)
(4)
NASA PIP, MRR(6)
(4)


THANK YOU!

Validation Site

NMSC

Period: JJA 2017

Site name	Site ID	Lat (°N)	Lon (°E)	Alt (m)
Jindo	JNI	34.471	126.328	499
Busan	PSN	35.115	129.001	547
Gosan	GSN	33.294	126.163	103
Seongsan	SSP	33.387	126.880	72
Baengnyeong	BRI	37.968	124.630	185
Myeonbong	MYN	36.179	128.997	1136
Gwanak	KWK	37.444	126.964	641
Gwangdeok	GDK	38.118	127.434	1061
Oseong	KSN	36.013	126.784	231
Gangneung	GNG	37.818	128.866	99
Yongin Test-bed	YIT	37.206	127.285	473
Biseul	BSL	35.694	128.535	1085
Sobaek	SBS	36.928	128.441	1408
Mohu	MHS	35.034	127.183	958
Seodae	SDS	36.225	127.543	922

KMA started to replace the radar network to S-band Dual polarization radar from 2013.
Black: Operated by KMA, Blue: Test-bed(KMA), Red: Operated by MOLIT